ENHANCING CAPACITY FOR LOW EMISSION DEVELOPMENT STRATEGIES (EC-LEDS) CLEAN ENERGY PROGRAM

COOPERATIVE AGREEMENT NO. 114-A-13-00008

Municipal Emission Inventory, Projection and Mitigation Planning Tool (muni-EIPMP)

September 2016

This publication was produced for review by the United States Agency for International Development. It was prepared by Winrock International in cooperation with Sustainable Development Center "Remissia"

ENHANCING CAPACITY FOR LOW EMISSION DEVELOPMENT STRATEGIES/EC-LEDS CLEAN ENERGY PROGRAM

Municipal Emission Inventory, Projection and Mitigation Planning Tool (muni-EIPMP)

September 2016

This is updated version of Municipal Emission Inventory, Projection and Mitigation Planning Tool (muni-EIPMP) reports submitted in September 2014 and September 2015 and reflects the changes made to the muni-EIPMP tool during the third year.

The authors appreciates the dedication of time and expertise provided by DecisionWare Group in testing the tool and providing valuable insights about its improvement.

TABLE OF CONTENTS

List of Tables

ACRONYMS

BAU	Business AS Usual (scenario)
BEI	Baseline Emission Inventory
CoM	Covenant of Mayors
EU	European Union
GHG	GreenHouse Gasses
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre
muni-EIPMP	Municipal Emission Inventory, Projection and Mitigation Planning Tool
NCV	Net Calorific Value
SEAP	Sustainable Energy Action Plan

EXECUTIVE SUMMARY

Tbilisi, the capital of Georgia and its largest city, was the first to join the Covenant of Mayors (CoM) and submit a Sustainable Energy Action Plan (SEAP). Tbilisi's SEAP was prepared by the Sustainable Development Centre Remissia with the financial support from USAID/Winrock. For Tbilisi's SEAP, a new methodology was developed and used, which differs from the methodology applied by the EU cities. In particular, a Business as Usual (BAU) scenario approach was offered instead of fixed base year approach applied by Annex I cities from the EU and former Soviet countries (Ukraine, Belarus).

Such approach encloses a city's development perspective and potential of increase in greenhouse gasses (GHG) because of development needs and demonstrates perspective of development with lower emission pathway. The LEAP (Long-Term Energy Alternative Planning) model was applied for the preparation of a BAU (Business As Usual) scenario by 2020 for the Transport, Building and public lighting sectors. While LEAP was developed at the city level, it drew many assumptions (such as elasticity and penetration rates) from the national MARKAL-Georgia model.

Once the BAU scenario was established GHGs emission reduction till 2020 was calculated below the BAU scenario and not against a fixed base year approach. This approach was appraised and approved later by Joint Research Institute (JRC) from EU, which is responsible to review the SEAPs. Based on this approach JRC developed a methodology for preparation of SEAP for Eastern Neighborhood and Central Asia countries [1] which allows the use of BAU scenario as reference for reductions, and included the comprehensive energy sector modeling effort from Tbilisi's SEAP as an example of how to use the BAU approach.

However, such comprehensive modeling effort is often out of the human, technical and financial capacities of municipality, since this approach requires more statistics and better technical capacity than are generally available at municipality level and thus cities are forced to seek outside support. As a response to removing this barrier, the JRC also introduced another, optional approach for COM Eastern Countries to project BAU scenario. Coefficients were developed at the Institute for Environment and Sustainability of the Joint Research Centre that are simply applied to a base year to project likely future emission levels. While, this approach is easier to apply at municipal level, it has several drawbacks: the growth rates are national thus they cannot incorporate the municipal growth rates which may differ; the differences of sectoral growth rates are not accounted for; the possible changes in economic and demographic projections at national level are not reflected. In addition, JRC has compared the national factors for 2005-2010 (result of the first five years projection) with the current IEA energy consumption data for the same period and significant discrepancies for Georgia have been observed in their projections [2].

Due to the above reasons, EC_LEDS proposed to develop a simpler inventory and projection tool for municipalities which would draw information from national MARKAL-Georgia model, such as Georgia-specific sector-specific emission elasticities rather than using generic JRC emission growth coefficients. In addition, the municipalities would be provided with other necessary information such as national emission factors, including projected carbon intensity factor for electricity, which will capture the impact of planned national actions as well as plans from other municipalities or regions.

Finally, specific SEAP measures that are common to many municipalities can be evaluated at the national level to identify the most attractive collective measures/programs, and so that basic cost and mitigation data can be provided to the municipalities to avoid duplication of effort and improve the consistency of the SEAPs. On the other hand municipal level data on building stocks, transport requirements along with expected mitigation measures and performance improvements would be aggregated in the enhanced MARKAL-Georgia model to increase the accuracy and validity of analyses performed at the national level. This approach ensures that actions and decisions taken at the national level will be properly incorporated in the municipal SEAPs, and that the cumulative influence of actions by the municipalities are properly accounted for in the national context.

This new tool has the following advantages: 1) It is simple enough to be successfully used at municipal level, but comprehensive enough to give the planners at municipal level the insights they require. 2) It is linked with national MARKAL-Georgia model (from Component 3) and obtains many necessary inputs from it to assess the GHG projections and mitigation potentials. 3) Linking with national model the consistency between different assumptions at municipal level that rely on national data (for emission factors, net calorific values, etc.) and data-sharing between different municipal models is achieved.

During the first year of EC-LEDS project, the modules for transport, buildings and public lighting were developed, which include submodules for data gathering, emission inventory calculations and BAU projections for these sectors up to 2020.

During the second year the following enhancements were made to the model:

1. The initial year for BEI was made to be flexible, so the users can choose the starting year of their analysis.
2. The last year of BAU scenario was also made to be flexible, so that emission projections can be valuated for the years after 2020 as well. This was done because 2020 is fast approaching and new municipalities have very small time to implement their mitigation action during remaining period. Thus the longer time scale for BAU is more appropriate for them.
3. The options for BAU methodologies were added. User can choose from MARKAL projections, JRC projections or any other national projections that are available.
4. The module for wastewater was added. For solid waste the IPCC software can be used and integrated into muni-EIPMP. Modules include estimation of savings from mitigation measures.
5. The sheets for estimating mitigation effects and costs for different mitigation measures were also added. Sheets need to be populated with data form MARKAL analysis, or any other source.

During the third year the following enhancements were made to the model:
1. In the Muni_EIPMP MAIN module the function of automatic update of projections has been added, enabling the user to choose MARKAL, JRC or national projections from MAIN and automatically updating all other modules.
2. Module named Muni_EIPMP_BAU Input was created, which contains MARKAL, JRC, National and Local projections coefficients and also has conversion coefficients and emission factors for different types of fuel that are used for GHG inventory. All modules take formulas and coefficients from this module.
3. The combined tables and charts have been added to each module which gives the user visual information about situation in each sector and subsectors.
4 Measures sheet was added (or/and updated, simplified) to each modules. Now user can choose some measure and rapidly assess its effect of GHG Emissions reduction.
5. Public Lighting module deserves special mention because more comprehensive versions of BAU and SEAP scenario development have been added considering such factors as penetration of public lighting, electricity losses, electricity emission factors by years, etc.
6. Projections from latest MARKAL-Georgia BAU scenario have been incorporated into muni-EIPMP.

SECTION ONE: METHODOLOGY

1.0 INTRODUCTION

The CoM process in Georgia started in 2010, when Tbilisi joined it. Later seven more cities have joined the process and stated to work on the development of SEAPs. The experience of working with them and lessons learned in the process make the foundation of the requirements and specifications for muni-EIPMP.

The needs of municipalities for support in the CoM process fall into four categories as discussed below:

1. **Support in data gathering**. Data gathering is the initial critical step in the SEAP preparation and implementation process, as it is needed to gain a proper understanding of emission sources and amounts from the territory of municipality. It remains an important component of the process even after submitting the SEAP, because municipalities should continue gathering such data to monitor the success of its implementation activities. Not all the data necessary to develop the Baseline inventory and assess the mitigation measures at municipal level is readily available. Only very few is currently collected for the assessment of economic activities. Some data valuable for the SEAP preparation and monitoring are collected by the private sector for their own purposes and belong to private sector (such as distribution companies, etc), who are not always willing to share them. Often the municipalities don't know all the sources of data, and even when a municipality is successful in obtaining some data, it is not usually in the format and structure that is required by the SEAP. Data from different sources can contradict and require strong validation. Some required data (e.g. transport mileage) has not been accurately quantified and must be estimated. The municipalities don't have the capacity and knowledge to develop such data if it is not readily provided by some external entity. The experts from abroad who provide support to municipalities in many cases are not aware of such difficulties and don't know how to face them. This was the main reason why Tbilisi was not able to develop its baseline inventory (despite support from GIZ and INOGATE) for SEAP. It is also the reason other cities, like Rustavi and Gori couldn't produce complete inventory. So the tool which will allow making necessary adjustments to data accompanied with detailed instructions on data gathering procedures and training on the use of the data collection workbooks will help municipalities to develop their baseline inventory.

2. The second most important aspect of a successful SEAP process is **developing mitigation measures and project proposals,** which will lead the municipality towards their mitigation target. Even if the SEAP is developed and given to a municipality, without the specific actions and projects it is just paperwork. The level of understanding among the municipal planners of energy issues, emissions, energy efficiency and renewable energy options, mitigation activities in non-energy sectors is very low. Where some understanding exists, there is no knowledge of how to translate it into information to guide decision-making. During many workshops some municipal staff have gathered information on possible measures, but without hands-on experience developing projects they are not able to apply them. So municipalities need on-the-job training for developing specific project proposals for their SEAP and technically and financially assessing them.

3. **The tool for emission inventory compilation, development of Business As Usual (BAU) Scenario and quick assessment of mitigation options for SEAP**. Georgian cities have the possibility to calculate mitigation target against a BAU scenario, and not against some base year for European cities. This ensures that CoM commitment doesn't act

as a barrier to economic development of city, rather it facilitates sustainable development. Municipalities need both a simple tool, which it can successfully apply and sustain, and a tool that has more Georgia-specific data. The tool should be in familiar format (preferable Excel), make possible to adjust the emission growth projections using municipalities economic and demographic growth parameters, but shouldn't concentrate deeply in development of BAU. The tool should also help them to prioritize different mitigation options applicable to Georgia and quickly assess their mitigation potential and costs. As already said, it is important that municipalities concentrate on data gathering and development of specific mitigation measures and proposals, and not comprehensive modeling efforts, which need significant time and skill. In best case the tool should cover all emission sectors, including energy and non-energy sectors.

4. **Targeted capacity building**. Despite many capacity building workshops organized by different organizations and donors for municipalities, the capacity of municipal staff is still very low. We believe that the main reason behind this unsuccessful capacity building activities is misunderstanding of municipal needs and unrealistic judgment of their real capabilities. So all capacity building workshops and trainings should be targeted to particular needs and aim to develop specific capacities in municipal staff.

To address the above discussed needs of municipalities and make the efforts successful and sustainable, it was decided to develop the special tool, the Municipal GHG Emission Inventory, Projection and Mitigation Planning Tool (muni – EIPMP). It is in Excel (software already familiar to the municipal staff and easily maintainable), and it is designed to guide the municipal staff to directly fill in the CoM SEAP templates, used by municipalities for CoM reporting.

Muni –EIPMP includes three features:

- The methods for activity data calculation and establishment of baseline inventory (BEI)
- Calculation of Business as Usual Scenario (BAU) projections
- Assessment of different mitigation options

Among these the inventory and BAU modules (first two features) for transport, building and public lighting have been developed during year 1, and module for the assessment of mitigation measures - during year 2. In addition, during year 2 the flexibility of choosing the starting and ending years of analysis, choosing of methodology for BAU development and waste modules were added. During year 3, muni-EIPMP has been farther tested and refined and projections from latest MARKAL-Georgia BAU scenario have been incorporated.

1.1. Description of Methodology

1.1.1. Baseline Emission Inventory (BEI)

The Baseline Emissions Inventory (BEI) quantifies the amount of GHGs emitted in the territory of the local authority (i.e. Covenant signatory) in the baseline year. It allows for identification of the principal anthropogenic sources of CO_2 emissions and to prioritise the reduction measures accordingly. The local authority may include also methane (CH_4) and nitrous oxide (N_2O) emissions in the BEI.

The methodology that muni-EIPMP uses to calculate emission from fuel combustion is based on Revised 1996 IPCC guidelines [3], which is used for countries to report their GHG inventory to the UNFCCC and completely in line with the CoM guidelines.
Greenhouse gas emissions are calculated with formula adapted for intergovernmental council's (IPCC) methodology level 1 sector approach for local level which is based on actual fuel consumption data.

Formula 1

$$\text{Carbon Dioxide emissions}_j\ (GgCO_2) = \sum_i\{\text{Actual fuel consumption}_{ji}\ (\text{unit}) \times \text{Net Caloric Value of fuel}_i(\text{MWh}^1/\text{per unit}) \times \text{carbon emissions factor (tC/MWh)}/1000 \times \text{oxidation factor i}\} \times 44/12,$$

Where lower index j refers to sector and lower index *i* - type of fuel.
Emissions for other gases with sector approach were calculated via following formula:

Formula 2

$$\text{Greenhouse gas emissions}_j\ (\text{GgGas}) = \sum_i\{\text{Actual fuel consumption}_{ji}\ (\text{unit}) \times \text{Net Caloric Value of fuel}_i(\text{MW.h/per unit}) \times \text{Gas emissions factor}_{ji}(\text{t Gas/MW.h})/1000].$$

The approach ensures that emission factors and converters (Net Calorific Values) that have been used in MARKAL-Georgia and muni-EIPMP are the same. The emission factors are based on national GHG inventory, whereas convertors are taken from National Energy Balance developed by National Statistics Office of Georgia. Only exception is biomass, where the converter is based on values developed by Remissia experts, working on buildings sector analysis in various municipalities. The tables 1,3, and 4 indicate these numbers.

Table 1. Converters and Carbon Emission Factors for Different Types of Fuel

Type of Fuel	Unit	Transfer Coefficient (MW/h unit)	Carbon Emission Factor (Ton C/ MW.h)
Gasoline	1000 tons	0.012	0.247
Diesel	1000 tons	0.012	0.267
Liquid Gas	1000 tons	0.013	0.227
Natural Gas	1 millionm^3	0.009	0.202
Firewood	1000 m^3	0.003	--

The Average emission factor of grid electricity depends on the year of analysis and is obtained by dividing CO2 eq. emissions from national power sector in that particular year by final energy consumption of electricity in the country. The projections of electricity grid emission factor from MARKAL-Georgia are shown in Table 9. It should be mentioned that all factors are located in separate muni-EIPMP module that can be updated when emission factor or converter changes.

A small portion of carbon in fuel is not oxidized during combustion and are accounted for in formula 1. Typical values of oxidized carbon recommended by IPCC and used in 2006-2011 national inventory are given below. (Table 2). These are used in MARKAL-Georgia and muni-EIPMP as well.

Table 2. Oxidation factors for Different Fuels

Fuel	Share of Oxidized Carbon
Oil and Oil Products	0.990
Natural Gas	0.995

[1] Basic energy unit in IPCC methodology is Terajoule, while according to the SEAP methodology it is MW/h, that is why MWh is used here everywhere

Other GHG emission factors for transport and buildings sectors are given in Table 3 and Table 4.

Table 3. Methane and Nitrous Oxide Emission Factors for Transport Sector (kg/MWh)

Greenhouse Gas	Gasoline	Diesel	Natural Gas
CH_4	0.072	0.018	0.18
N_2O	0.002	0.002	0.0004

Table 4. Methane and Nitrous Oxide Emission Factors for Buildings (kg/MW/h)

Greenhouse Gas	Natural Gas	Oil Products	Firewood
CH_4	0.018	0.036	1.08
N_2O	0.00036	0.002	0.014

Global warming potential values (GWP) of mentioned gases are used for converting methane and nitrous oxide into carbon dioxide equivalent.

Table 5. Global Warming Potential of Methane and Nitrous Oxide

Gas	Life Expectancy, Years	100-year GWP
CH_4	12±3	21
N_2O	120	310

The methodology used for estimation of GHG emissions from the waste sector is based on those recommended by the IPCC guidelines usually used by national GHG inventory compilers. The methodologies of these GLs are considered as the most relevant to estimate GHG emissions as they reflect the actual level of science and knowledge in the area. The main IPCC guidance documents are:

- *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (*1996*)

- *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000)*

- *2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006)*

These documents are consistent and complementary to each other, reflecting the natural process of improvement in the assessment of GHG emissions, made throughout time. For waste water, simple tier 1 method is used in muni-EIPMP and for landfills, muni-EIPMP method supports the use of higher tier, Firs Order Decay method.

1.1.2. Development of BAU

Guidance document [1] has been developed by the Joint Research Centre (JRC) specially for the Eastern Partnership member cities, according to which these cities are given a choice to determine mandatory reductions of emissions through three alternative approaches:

- Reduction of absolute emissions against fixed base year;
- Reduction of absolute per capita emissions against fixed base year;
- Reduction against prospective emissions of 2020 according Business As Usual (BAU) scenario.

Abovementioned guidance describes two possible versions of scenario construction:

- The city can develop its own methodology, which later will be evaluated by the JRC.
- The city may use national coefficients indicated in the guidance. These coefficients have been developed for the Global Atmosphere Research (EDGAR) project CIRCE[4] employing emissions database. There has also been used POLES (Prospective Outlook for the Long-term Energy Systems) [5,6] method, considering growth of energy consumption due to population and economic growth. According to the baseline year, the BAU scenario calculates level of emissions for 2020 assuming that current trends of population, economy, technologies and human behavior will continue and no national measures will be taken towards reduction of emissions. The coefficients are indicated in Table 6:

Table 6. JRC National Coefficients for Buildings and Transport Sectors

BAU projec-tions	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ARM	1.24	1.25	1.27	1.28	1.29	1.31	1.28	1.25	1.23	1.20	1.17	1.14	1.11	1.07	1.04	1.00
AZE	1.98	1.96	1.95	1.93	1.91	1.87	1.78	1.69	1.61	1.52	1.42	1.33	1.25	1.17	1.08	1.00
BLR	1.09	1.09	1.10	1.10	1.10	1.10	1.10	1.09	1.08	1.07	1.05	1.04	1.03	1.02	1.01	1.00
GEO	1.66	1.65	1.64	1.63	1.62	1.61	1.55	1.49	1.42	1.36	1.30	1.24	1.18	1.12	1.06	1.00
KAZ	1.11	1.10	1.09	1.09	1.08	1.07	1.06	1.06	1.05	1.04	1.04	1.03	1.02	1.01	1.01	1.00
KGZ	1.47	1.52	1.57	1.62	1.67	1.72	1.66	1.59	1.52	1.45	1.39	1.31	1.24	1.16	1.08	1.00
MDA	1.17	1.20	1.22	1.24	1.26	1.27	1.25	1.23	1.20	1.18	1.15	1.12	1.09	1.06	1.03	1.00
TJK	2.78	2.76	2.73	2.71	2.68	2.56	2.39	2.23	2.07	1.91	1.70	1.56	1.42	1.28	1.14	1.00
TKM	0.98	0.98	0.99	1.00	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.00	1.00	1.00	1.00
UKR	0.98	0.99	0.99	1.00	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.00	1.00	1.00	1.00
UZB	1.54	1.50	1.46	1.42	1.38	1.32	1.29	1.26	1.22	1.19	1.15	1.12	1.09	1.06	1.03	1.00

The emissions in 2020 are calculated as:

Formula 3

$$\text{Emissions}_{2020} = \\ = \text{Emissions}_{BY} \times \text{Coefficient}_{BY}$$

Where Emissions_{2020} are emissions in 2020, BY is base year, and Coefficient_{BY} is coefficient from Table 6 for corresponding base year.

While, this approach is easier to apply at municipal level, it has several drawbacks: the growth rates are national thus they cannot incorporate the municipal growth rates which may differ; the differences of sectoral growth rates are not accounted for; the possible changes in economic and demographic projections at national level are not reflected. In addition, JRC has compared the national factors for 2005-2010 (result of the first five years projection) with the current IEA energy consumption data for the same period and significant discrepancies for Georgia have been observed in their projections.

Muni-EIPMP has flexibility of choosing the approach for development of BAU. The user can choose to develop BAU projections based on JRC coefficients[2] or based upon national projections existing within the country. The projections can be from MARKAL-Georgia or any other source but it is important that they should be given for each sector (and/or subsector) individually.

If the national coefficients are applied, they can be downscaled to the municipal level. To do this the user has to include the local level projections of population and GDP.

[2] Note that JRC coefficients are available only until 2020.

This approach has the following advantages: 1) It is simple enough to be successfully used at municipal level, 2) It gives projections at sectoral level that gives the planners at municipal level the insights they require. 3) It is linked with national projections (from Component 3 or INDC or MARKAL) and thus the national policy and BAU are properly accounted for at municipal level. 4) If there exists projections of main demand drivers (population growth and GDP growth) at municipal level they can be incorporated to adjust national coefficients to local level.

The emissions are calculated as:

Formula 4

$$\text{Emissions}_{s,t} = \\ =\text{Emissions}_{s,BY} \times \text{Coefficient}_{s,t} \times \text{population\_correction\_factor}_t \times \text{GDP\_correction\_factor}_t$$

Where s represents the sector, t represents the year for which emissions are calculated, BY is base year, and Population_correction_factor and GDP_correction factor represent the ratio of projected municipal growth rates (population and GDP corrspondingly) with the national growth rates. If the local projections don't exist, these factors equal to 1.
During year 3 the emission growth coefficients from latest MARKAL-Georgia BAU scenario have been incorporated in muni-EIPMP. Shows growth coefficients for transport sector, and for buildings sector up until 2030. Shows the projections of electricity grid emission factors from MARKAL-Georgia BAU scenario.

Table 7. MARKAL-Georgia emission growth coefficients for transport

Transport type	2014	2016	2018	2020	2022	2024	2026	2028	2030
Transport buses	1.000	1.005	1.011	1.017	1.010	1.014	1.019	1.030	1.042
Transport Heavy Goods Vehicles	1.000	1.121	1.308	1.482	1.671	1.879	2.082	2.308	2.535
Transport Light Commercial Vehicles	1.000	1.072	1.201	1.318	1.449	1.596	1.759	1.950	2.151
Transport Light Duty Vehicles	1.000	1.091	1.243	1.407	1.597	1.689	1.788	1.895	2.009
Transport Mini-buses	1.000	0.907	0.813	0.720	0.627	0.535	0.442	0.448	0.453
Transport two wheelers	1.000	1.029	1.176	1.311	1.470	1.539	1.617	1.691	1.791

Table 8. MARKAL-Georgia emission growth coefficients for buildings

Buildings type	2014	2016	2018	2020	2022	2024	2026	2028	2030
Commercial and Municipal Buildings	1.000	1.065	1.164	1.254	1.371	1.502	1.633	1.762	1.916
Residential Buildings	1.000	1.074	1.213	1.368	1.549	1.738	1.927	2.100	2.263

Table 9. MARKAL-Georgia projections for electricity grid emission factor

parameter	2014	2016	2018	2020	2022	2024	2026	2028	2030
Electricity EF (kg CO_2/kwh)	0.1153	0.1206	0.1171	0.1143	0.1118	0.1096	0.1331	0.1295	0.1264

The BAU projections for public lighting are based on separate, module specific assumptions (such as number of lighting bulbs planned to be added to public lighting in future year, number of population that connected to sewage system, etc.) and are discussed under the descriptions of the corresponding modules.

For waste, the BAU development uses same methodological approaches, as for BEI, but with assumption on growth of population connected to sewage system (in case of wastewater) or served by landfill (in case of solid waste). All other calculations remain the same as for BEI.

SECTION TWO: DESCRIPTION OF MUNI-EIPMP

2.1. Overall description of muni-EIPMP

Municipal GHG Emission Inventory, Projection and Mitigation Planning Tool (muni – EIPMP) is developed in the environment of Excel (software already familiar to the municipal staff and easily maintainable), and is designed to guide the municipal staff to directly fill in the CoM SEAP templates, used by municipalities for CoM reporting.

Current version of muni-EIPMP has 7 interlinked modules (workbooks) discussed below. Each workbook includes instruction of use on the first "MAIN" worksheet and sometimes on other sheets as well.

- Muni-EIPMP_Start is the starting module which includes Visual basic code for creating new inventory or opening existing one. The code also enables to set up the initial year of analysis, end year of analysis and select the methodology for BAU modeling. It also creates sectoral modules for newly created inventory.
- Muni-EIPMP_MAIN – the main workbook is were inventory for base year (BEI) and BAU projection are assembled. It reads the fuel consumption values for different sectors from sectorial modules, performs the energy unit conversions and calculates emissions of CO2, CH4 and N2O. The structure of fuel consumption and inventory sheets are identical with CoM SEAP templates.
- Muni_EIPMP_Buildings is a sectoral workbook, which includes data entry sheets required for inventory and mitigation planning in this sector, as considered under SEAP. This workbook also includes a BAU scenario worksheet, which takes emissions for the base year and calculates emissions for the BAU scenario based on MARKAL-Georgia, JRC or National projections taken from the Muni_EIPMP_BAUInput workbook. Also additional sheets "Actions" and "Actions Template" were added that support the evaluation of mitigation measures.
- Muni_EIPMP_Transport is a sectoral workbook, which includes a data entry sheet (Transport data) required for inventory and mitigation planning in this sector, as considered under SEAP. This sheet requires data on vehicle numbers and fuel efficiency by fuel type and vehicle type and mode, and calculates final energy use. Energy Consumption worksheet takes values from input data worksheet (energy consumption in natural units) and converts it to TJ and MWh. The CO2,CH4,N2O emissions worksheet takes values from Energy Consumption worksheet and calculates CO2, CH4, N2O and total emissions. The BAU scenario worksheet takes emissions for the base year and calculates emissions for the BAU scenario based on MARKAL-Georgia, JRC or National projections taken from the Muni_EIPMP_BAUInput workbook. The "measures" worksheet supports the evaluation of mitigation measures.
- Muni_EIPMP_Public Lighting is a sectoral workbook, which include sheets for data entry required for inventory and mitigation planning in this sector, as considered under SEAP. Public Lightings(BAU) worksheet has table that should be filled with data of base year Public

Lighting information (lamp types, lamp's Electricity consumption, lamp quantity, working hours) and then using helper table it's easy to fill BAU scenario data, ie to add additional lamps from base year till last year of scenario. The other way to fill BAU data is to use penetration of Public Lighting in BAU worksheet from base year until last year of scenario. No other BAU projections are available in this workbook. Public Lightings(SEAP) worksheet takes data from Public Lightings(BAU) worksheet and then using helper table it's easy to fill SEAP scenario data, i.e. to replace existing non-energy efficient lamps with efficient ones. Public Lightings(SEAP) worksheet evaluates impacts of mitigation measures.

- Muni_EIPMP_waste is a sectoral workbook, which estimates emissions from wastewater and landfills. All calculations necessary for estimated wastewater emissions are incorporated into the workbook, while landfill emissions should come from somewhere else. For example they can come from the IPCC spreadsheet for solid waste inventories. The workbook includes also the calculation for mitigation measures from both wastewater and landfills, which assumes the collection of methane at some rate and either flaring it or venting.
- Muni_EIPMP_BAUInput has MARKAL-Georgia, JRC and National coefficients which are used to project BAU scenario in Buildings and Transport sectors. Also worksheet Local Projections contains assumptions on municipal-level GDP and population growth that are used for downscaling national emission projections to a local level. If there are changes to the BAU scenario in MARKAL-Georgia, this workbook can be automatically filled by VedaBE software (part of MARKAL platform) and sent to each municipality, which will then update links in other muni-EIPMP workbooks (by open each and saving after replacing the Muni_EIPMP_BAUInput workbook) to get updated BAU projections for their municipalities. Also workbook has Coeffs worksheet which contains all transfer coefficients for formulas in other workbooks.

The initial set-up of muni-EIPMP consists of one workbook called "START" and a folder that holds all other workbooks. To start working with muni-EIPMP, the user has to open START module[3]. The following window appears:

Figure 1. The start screen of muni-EIPMP

[3] If macros are not automatically enabled, the user has to enable them manually.

After pressing “continue” the user is prompted to either create new inventory or open existing one. If user chooses “new”, new window appears where the user has to enter the name of municipality and starting and end years of analysis.

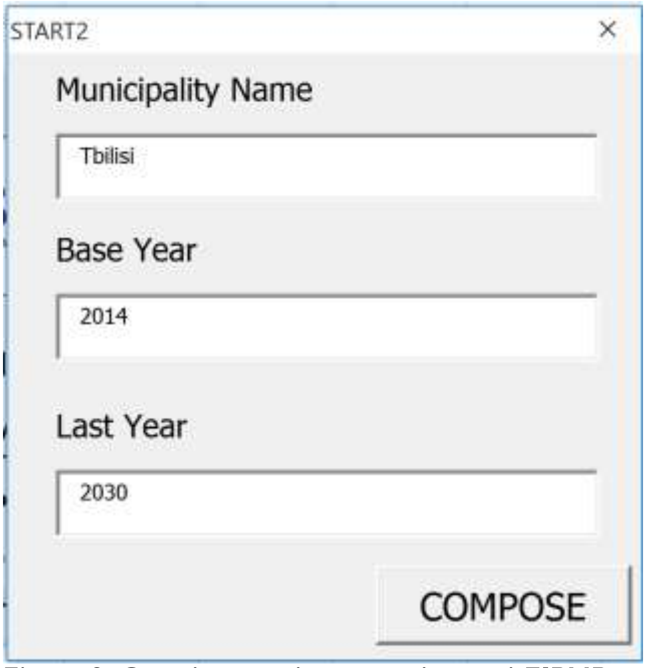

Figure 2. Creating new inventory in muni-EIPMP

After pressing “Compose” the new folder will be created, the name of which consists from municipality name and start year of analysis. It will hold all modules for this analysis in it.
Later the user will be able to open it by pressing the “open” button instead of “new”.

After the new inventory is created (or existing one is opened) the start workbook will present the selection of different sectoral modules, which can be opened by pressing the corresponding buttons. The buttons will open the sectoral modules, where the user can input the data and view the results.

Figure 3. the start screen with selection of modules

The modules are described bellow in more detail.

2.2. Main Workbook

The “Muni_EIPMP_MAIN” is the main workbook and is used to assemble the complete inventory from all workbooks. It includes “MAIN” sheet which gives description of workbook and 5 other sheets.

- Sheet "Final energy (b. year)" consists of 3 tables":

1. "A. Final Energy consumption" where energy consumption is given in natural units (KWh, Kg, l, etc.) by categories. These values are gathered from buildings, transport, public lighting and waste modules;
2. "A. Final Energy Consumption (TJ)" where fuel consumption is converted from natural units to terra Joules;
3. "A. Final Energy Consumption (MWh)" where fuel consumption is converted from natural units to MWh;

- Sheet "CO_2, CH_4, N_2O emissions (b. year)" contains 4 tables:

1. "B. CO_2 or CO_2 eq. emissions" where CO_2 emissions from all sectors are calculated;
2. "B. CH_4 emissions" where CH_4 emissions from all sectors are calculated;
3. "B. N_2O emissions" where N_2O emissions from all sectors are calculated;
4. "B. total emissions" where CH_4 and N_2O emissions are converted into CO_2 eq. emissions (by using GWP values) and all emissions are summed in CO_2 eq. emissions.

None of the sheets listed above are editable because all values are calculated automatically.

- Sheet "BAU" shows projections of different emissions. Values are gathered from appropriate working files. The methodology for calculating BAU can be selected in cells A1:A2, or in the sectoral modules themselves. There are 3 types of BAU methodology– MARKAL, JRC, National and coefficients of emission growth from these methodologies are taken from BAU_Input file.
- Sheet "Graphs" contains tables and graphs that show total fuel consumption, emissions and emission reductions that is easily applicable in SEAP document.
- Sheet "Actions" contains a list of actions in different sectors of SEAP. It must be filled for records and also for constructing graphs on "Graphs" sheet.

2.3. Transport Workbook

The "Muni_EIPMP_Transport" is the workbook for Transport sector. It includes "MAIN" sheet which gives description of workbook and 4 sheets other sheets, described below:

- The first sheet "Transport_data" is the main sheet and is used for filling in data on transport stock in given municipality. It includes number of transport by fuel types, information about their fuel consumption and annual mileage. The user must fill yellow-painted cells and total consumption of different fuel types and emission values will be calculated automatically. Two following sheets are automatically filled with this sheet.
- Sheet "BAU" is used for creating "Business As Usual" scenario for transport sector until the last year of the analysis. Methodology that leads to calculating this table is given in A2 cell. This sheet also contains a graph of baseline scenario.
- Sheet "tables and graphs for SEAP" contains ready to use tables for SEAP document.
- Sheet "measures" contains the list of typical measures in the transport sector and gives a user an opportunity to estimate emission reductions by these measures. User must input values (in percentages) of reductions of energy consumption and emissions in columns H and I, respectively for this. These numbers may be based on technical-economical researches or on other types of researches (e.g. estimations of mitigation measures using MARKAL-Georgia model or other).

2.4. Buildings Workbook

The "Muni_EIPMP_Buildings" is the workbook for Buildings sector. It includes "MAIN" sheet which gives description of workbook and 7 more sheets.

- Working with module starts by inputting data in "input data" sheet. Detailed information about fuel consumption in buildings subsectors must be entered on this sheet. Pay attention to fuel types and units, which cannot be changed. Standard types of buildings are listed in each subsector (e.g. multistory buildings, kindergartens, etc.) that can be changed if necessary.

After inputting information on this sheet, four sheets listed below will update automatically.

- Sheet "Energy Consumption" consists of 3 tables":

1. "A. Final Energy Consumption" where information about final energy consumption is given in natural units (KWh, kg, l, etc.) by categories. The source is sheet "input data";
2. "A. Final Energy Consumption (TJ)" where fuel consumption is converted from natural units to TJ;
3. "A. Final Energy Consumption (MWh)" where fuel consumption is converted from natural units to MWh.

- Sheet "CO_2, CH_4, N_2O emissions (b. year)" contains 4 tables:

1. "B. CO_2 or CO_2 eq. emissions" where CO_2 emissions are calculated;
2. "B. CH_4 emissions" where CH_4 emissions from incomplete combustion are calculated;
3. "B. N_2O emissions" where N_2O emissions from incomplete combustion are calculated;
4. "B. total emissions" where CH_4 and N_2O emissions are conversed into CO_2 eq. emissions (with the help of GWP values (conversion factors)) and all emissions are summed in CO_2 eq. emissions.

- Sheet "Tables for SEAP" contains ready to use tables for SEAP (Sustainable Energy Action Plan) document.

None of the sheets listed above are editable because all values are calculated automatically.

- Sheet "BAU" gives "Business As Usual" scenario for buildings sector until the last year of analysis. Starting and final years that are inputted when creating the scenario, are automatically transferred to cells A2 and A4, respectively. Methodology that is used for calculating this table (MARKAL, JRC, National) is described in cell A6. This value is MARKAL at the start and then it can be changed from MAIN file, as well as on this sheet. The sheet also contains chart of base year scenario together with graph of fuel consumption by fuel types.
- Sheets "Actions" and "Actions Template" contain a list of typical mitigation measures in buildings sector and gives user a possibility to estimate reductions of energy consumption and emissions in case the measure is implemented. For this estimation, user can use reductions of energy consumption (KWh/m^2) estimated by energy audits in those 7 cities of Georgia that are listed on "Actions Template" sheet. There are 2 buttons on this sheet:
    - First button – "Choose old" gives an opportunity to choose information of one of existing cities about reduction of energy consumption and use this information for your city. For this, user has to click the button, choose one of the cities, click button "Ready" and then choose those types of buildings on which he wants to hold activities. User can add a new type of building that does not exist in his city by clicking "Add" button on the upper right part of the window. The new type will be added in a list on the left side of a window. Then the user has to select it and move to the right list. After clicking "Choose" button B (building types) and H (reduction of energy consumption by activities (KWh/m^2) columns of the table in the sheet "Actions" are automatically filled. Then user has to fill yellow-painted fields. In the field "Used fuel type" user must write a type of fuel that is being used. Fuel types are listed in table A15 on the sheet "Actions". User must choose one of the given types and write it into a G column of an appropriate measure. Then the information about the amount of energy and emission savings after this or that measure will be calculated.
    - The second button on the sheet "Actions Template" is "Add new" that allows user to add his city. If user clicks the button, fills in the name of the city and clicks "Add", this city will be added to the list of every measure. Then the user must input the information about energy reductions and click the first button of this sheet "Choose old" and repeat the actions described above.

Adding new sheets in the module is possible to hold any additional information.

2.5. Public Lighting Workbook

The "Muni_EIPMP_PublicLighting" is the workbook for Public Lighting sector. It includes "MAIN" sheet which gives description of workbook and 5 more sheets.

- Filling the module starts with describing lamps that are used for public lighting and their mode of use. "Public Lightings (BAU)" sheet is responsible for this. Sheet "Public Lightings (BAU)" has 4 tables:
  1. The first table lists Lamp types, energy consumption by one lamp, number of lamps and working hours (per day) from base year until the final year. If we write any number in the yellow cell under "Working hours", this number will be automatically written in the same category of other years. Final energy consumption and emissions by years will be calculated with formulas.
  2. The second table that is given in CY11 cell is an indicator of electricity losses by years (in percentages).
  3. The third table contains emission factors of electricity for years 2012-2030.
  4. The fourth table is "Simpler Form" which givs simpler approach of filling of the first table and gives user an opportunity to add non-energy effective lamps equally by years. This table has 9 columns:
  1) "Count? (Y/N)" – if user wants to implement this measure, he has to input "Y", if not – "N";
  2) "Type of lamps to be added (non-energy effective)" – user must input types of lamps with Latin letters that he wants to add. Writing the first 3 letters of the type is enough for the program to guess the type of lamp;
  3) "Electricity consumption per one lamp (W)" - electricity consumption of one lamp per hour, in watts;
  4) "Distance that must be covered (m)" – here user enters the distance in meters that must be covered by additional lamps;
  5) "Distance between posts (m)" - distance between posts in meters;
  6) "Must be set on both sides of the road" – if "Y", lighting poles will be set on the both sides of a road, if "N", than just on one side;
  7) "Quantity" – if previous columns are filled correctly, program will automatically calculate number of lamps that is needed for lighting selected distance;
  8) "Starting year of adding" – year when implementation of the measure will start;
  9) "Final year of adding" – year when implementation of the measure will finish. It must be mentioned that number of years includes final year. So if a starting year is 2015 and final year is 2019, period of this measure is 5 years.
- Sheet "BAU" is a "Business As Usual" scenario for public lightings sector until 2030. It consists of 2 tables:
  1. The first table is a table of coefficients energy consumption growth from 2012 to 2030. Percentages of increase must be written only for first and final years and percentages of other years will be calculated automatically. If user writes "Y" in the cell "Use percentage indicator (Y/N)?" (A2), then these coefficients will be used in the second table that is a table of energy consumption of public lighting and is calculated so: if using percentage indicator is turned on ("Y") it takes growth coefficient, multiplies it by the value of base year and shows the result by years. If this indicator is turned off, it takes calculated energy consumption from the sheet "Public Lightings (BAU)" and writes it by years. In the same way, if we write "Y" in "Use electricity emission factor for next years", current (base year) emission factor is used for calculating values of each year. This factor is given in Public Lightings (BAU) -> CX2 table.

2. The second table shows energy consumption of public lighting from 2012 to 2030.

- Sheet “Energy Consumption” is being used for inputting data of electricity consumption of fountains and traffic lights. Values of base and final years of public lighting are automatically filled from the sheet “Public Lightings (BAU)“.
- The contents of the sheet “Public Lightings (SEAP)” is similar of the “Public Lightings (BAU)” sheet. The difference is that in this sheet energy efficient bulbs are used to cover future energy demand for public lighting instead of non-energy efficient bulbs used in BAU.
- There are two tables given on the sheet “Tables and graphs for SEAP”: energy consumption of public lighting is given in the first table by years and the second table shows emissions. Both tables include information for both, BAU and SEAP scenarios.

2.6. BAU Input Workbook

This is a working file of Muni-EIPMP BAUInput. It contains conversion coefficients and emission factors for different types of fuel that are used for GHG inventory. Here are also coefficients used in different methodologies for creating Business as Usual (BAU) scenario
There are 6 sheets in the workbook:

- “MAIN” sheet gives description of workbook in English and Georgian.
- Sheet “MARKAL” contains projections of emissions from fossil fuel combustion in different sectors and projections of electricity consumption for estimating indirect emissions of electricity from MARKAL-Georgia. Beside this, MARKAL-Georgia assumptions on GDP and population growth are given here. If national and local coefficients of GDP and population growth do not match, their ratio will be used for correcting national emission projections for use in municipal projections.
- If the name BAU scenario of MARKAL changes, new name must be filled in B7 cell on the sheet “MAIN” that will allow to change the name of this scenario in all sheets of the scenario by using “ScenAll” button. This will lead to proper update of data. In this case, this working file can be automatically updated by VEDA-BE software by EC-LEDS project team. After that, this file will be sent to the municipalities and then they will be able to update their BAU projections.
- Sheet “JRC” contains national coefficients of JRC baseline scenario that are used in case of choosing JRC methodology for creating baseline scenario by user.
- Sheet “National” contains national coefficients of BAU scenario that are received from any other source. It is used when a user does not want to use neither MARKAL nor JRC methodologies and has any other projection for national emissions or local projections.
- Sheet “Local Projections” contains assumptions on municipal-level GDP and population growth that are used for downscaling national emission projections to a local level.
- Sheet “Coeffs” contains conversion coefficients and emission factors for different types of fuel together with grid emission factor of electricity and its projections.

2.7. Waste Workbook

The “Muni_EIPMP_waste” is the workbook for waste sector. It includes “MAIN” sheet which gives description of workbook and 7 other sheets, 5 them are intended for wastewater modeling and remaining two for solid waste

- The worksheet "Input_wastewater" has three tables. In the first one the user shall enter population numbers and the share of population who are connected to sewage systems in base year and projections of this share. The number of population connected to sewage is then calculated based on this data. In the second table the user must enter the information on industrial wastewater. the third table includes additional parameters by year (if user doesn't enter them, then default values will be used).

- The sheet "Wastewater_mitigation" calculates the emission reductions from mitigation measure for wastewater. The user has to indicate what percentage of methane will be collected and whether it will be flared or vented.
- The sheet "Domestic wastewater" takes data from the sheet"Input_wastewater", makes calculations and presents net methane emissions from base year until the end year.
- The sheet "Industrial wastewater" calculates the total organic waste water from industry by years.
- The sheet "Wastewater_BAU" sums the domestic and industrial wastewater and presents the total by year. It also shows the difference between BAU scenario and mitigation case.
- The last two sheets are intended for calculating methane emissions from landfills. The sheet includes information about opening and closing year of landfill, as well as base year. The user has to input the data on population numbers, the share of population that is served by landfill and other parameter for all years from the opening year of the landfill. For some parameters (i.e. waste composition) default values are used if the user doesn't fill the information. The information entered in this sheet is then processed by "IPCC_Waste_Model" which calculates emissions for the landfill, shown in the sheet "Landfill BAU".
- The sheet "Waste_BAU" shows the total emissions from both wastewater and solid waste.
- The sheet "Landfill_mitigation" calculates the emission reductions from mitigation measure on landfills. The user has to indicate what percentage of methane will be collected and whether it will be flared or vented.